Pest Management in Horticultural Ecosystems
Vol. 25, No.1 pp 37-43 (2019)

Seasonal variability of chiku moth, *Nephopteryx eugraphella* (Ragonot) in relation to ecological parameters and crop phenology of sapota

K. D. BISANE

ICAR-AICRP on Fruits, Fruit Research Station, Navsari Agricultural University, Gandevi-396 360, Gujarat, India

***E-mail:** kdbisane@yahoo.co.in

ABSTRACT: The infestation status of chiku moth/leaf webber, *Nephopteryx eugraphella* (Ragonot) in sapota was studied from April 2015 to March 2018.The chiku moth infestation was observed throughout the year with two phases of crest damage during May-June (7.24-8.86%) at peak flowering stage and during December (8.76-9.42%) at new foliage and fruiting initiation stage. Regarding correlation, chiku moth activity was mainly concerned negatively with preceding and current morning relative humidity during all three years of investigation. The regression equation was found non-significant with all ecological factors except preceding and current morning relative humidity during 2015-16 and 2017-18 as well as bright sunshine hors in 2017-18. Chiku moth peak infestation was associated with crop phenology which coincides with encouraging event of winter and summer seasons and peak flush of foliage and flowering phase under throughout year incidence pattern.

Keywords: Seasonal variability, Chiku Moth, *Nephopteryx eugraphella,* Sapota, Crop phenology

INTRODUCTION

Sapota [*Manilkara achras* (Mill.) Fosberg] has a continuous overlapping flowering and fruiting throughout the year under south Gujarat agro-ecological situation. Under such circumstances, pest menace is one of the major issue in boosting the productivity of the crop due to big span of 10-11 months between flowering initiation to fruit maturity stage. Currently, the Gujarat state produces about 325.15 thousand MT from an area of 25.56 thousand ha having productivity of 11.0 MT/ha (Anonymous, 2017). During last five year, Gujarat has stable area with slight increase in production and productivity.

Previously, sapota was not much damaged by insect pests and not a serious problem in orchards, but now incidence of major insect pests along with many minor and sporadic pests have been reported during last two decades. There are about 33 pests have been reported on sapota tree in India. Earlier, about 16 insect pests and mites from sapota were identified in last two decades back in Gujarat (Patel, 2002) and now 23 insect and mites pests are noted with expanding acreage of sapota in Gujarat under different phases of crop round the year (Bisane, *et al.*, 2018).

Among the bud boring lepidopteran insect pests, chiku moth/leaf webber, *Nephopteryx eugraphella* (Ragonot) (Lepidoptera:Pyralidae) and bud borer, *Anarsia achrasella* Bradley (Lepidoptera : Gelechiidae) are key pests of sapota causes damage to leaves and flower buds. The larvae of bud borer and chiku moth are considered to be key factors affecting the yield potential of sapota and about 25-27% yield loss due to both bud boring complex pests of sapota was noted under south Gujarat condition (Bisane, 2018). Therefore, the present approach was investigated to prepare pest occurrence prediction trend and damage distribution pattern of chiku moth in relation to ecological parameters and crop phonological phases in sapota agro-ecosystem under south Gujarat condition.

MATERIALS AND METHODS

The current study on seasonal variability of chiku moth/leaf webber (*N. eugraphella*) was investigated in sapota orchard of Fruit Research Station, Navsari Agricultural University, Gandevi (20.807545º N 73.022260º E) during three consecutive year of 2015-16, 2016-17 and 2017-18 under ICAR-AICRP (Fruits) programme. The field of sapota orchard cv. Kalipatti of about more than 30 years old trees planted at 10 x 10 m spacing under recommended cultivation practices kept free from any insecticidal spray was observed for pest incidence. For this purpose, twenty trees were randomly selected. On each tree, 3 twigs were selected and thus 60 twigs in all directions from tree periphery were observed fortnightly for the incidence of chiku moth. The total number of buds as well as damaged buds were counted on each twig and the per cent bud damage was calculated.

To assess the influence of various abiotic factors on seasonal abundance of chiku moth, the linear correlation coefficient was determined for previous and

Table 1. Bud damage variation due to chiku moth with respect to different crop phases of sapota (2015-18)

Month	FN	Bud damage (%)				Crop stage
		2015-16	2016-17	2017-18	Avg.	
April	**I**	5.88	6.65	7.69	6.74	Peak flowering & Fruiting
	II	5.77	6.94	8.39	7.03	
May	**I**	5.45	9.68	10.50	8.54	
	II	5.31	10.78	10.48	8.86	
June	**I**	4.88	9.12	10.00	8.00	
	II	4.07	8.22	9.42	7.24	
July	**I**	3.53	6.69	7.22	5.82	Fruit setting and development
	II	2.91	5.41	5.56	4.62	
August	**I**	2.30	4.83	2.91	3.35	
	II	2.65	3.60	2.87	3.04	
September	**I**	2.31	3.51	2.76	2.86	
	II	2.82	4.40	3.64	3.62	
October	**I**	3.76	5.05	5.03	4.61	New foliage & fruiting initiation
	II	4.86	5.54	3.54	4.64	
November	**I**	6.57	6.37	5.64	6.19	
	II	8.31	7.29	6.42	7.34	
December	**I**	9.73	8.81	7.73	8.76	
	II	9.44	9.77	9.04	9.42	
January	**I**	8.82	6.85	8.55	8.08	Peak fruiting & flowering initiation
	II	7.33	4.96	6.34	6.21	
February	**I**	5.86	3.36	5.19	4.80	
	II	3.13	3.70	3.88	3.57	
March	**I**	3.86	5.40	2.78	4.01	
	II	4.28	6.67	4.52	5.15	

Table 2. Linear correlation of chiku moth with weather factors in sapota (2015-18)

Year	Temperature (^{0}C)		Relative Humidity (%)		Bright sunshine hrs	Rainfall (mm)	Evaporation (mm/ day)
	Max.	Min.	Mor.	Eve.			
2015-16	0.071	-0.523**	-0.688**	-0.696**	0.569**	-0.448*	0.030
	(-0.252)	(-0.640)**	(-0.569)**	(-0.632)**	(0.525)**	(-0.373)	(-0.070)
2016-17	0.129	0.097	-0.651**	-0.348	0.222	-0.459*	0.693**
	(0.171)	(0.126)	(-0.520)**	(-0.205)	(-0.009)	(-0.316)	(0.563)**
2017-18	0.232	0.000	-0.668**	-0.279	-0.150	-0.304	0.594**
	(0.063)	(0.089)	(-0.448)*	(-0.005)	(-0.384)	(-0.29)	(0.358)

* Significant at 5% level and ** at 1% level.
# Value in parentheses are current fortnight's data and values in outside are preceding fortnight's data.

current fortnight's weather parameters collected from same location of FRS, NAU, Gandevi. The fortnightly bud incidence (Y) was correlated with different meteorological parameters *viz.*, maximum (X_1) and minimum (X_2) temperature; morning (X_3) and evening (X_4) relative humidity; bright sunshine hrs (X_5); rainfall (X_6) and evaporation (X_7). The bud infestation was further analyzed in regression equation to measure the per cent variability with chiku moth incidence elucidated by each weather variables for previous and current fortnight's weather factors. Furthermore, again regression equation prepared with major weather parameters *viz.*, maximum (X_1) and minimum (X_2) temperature; morning (X_3) and evening (X_4) relative humidity and rainfall (X_6) to check crucial weather factors (s), which were significantly associated with chiku moth infestation level. The prediction trend of the pest was calculated on current fortnight's weather data along with the per cent error variation between observed and predicted bud borer incidence during every year of investigation.

RESULTS AND DISCUSSION

Chiku moth/leaf webber (*N. eugraphella*) initially makes a bunch web of leaves by silken thread and feeds inside by cutting the leaf. Thereafter, the caterpillars bore through the basal part of the flower bud and eat completely inner content making bigger sized holes as compared to that of bud borer. In pest occurrences, the damaged buds leads to failure of flower setting or retention in the form of fruits and ultimately cause yield loss.

Under investigation period, this pest damage reported on sapota reproductive parts throughout the year in more or less intensity due to overlapping pattern of flowers under south Gujarat agro-ecological situation (Table 1). The pest calendar was prepared on the basis of the pest incidence data (Fig. 1). However, chiku moth damage intensity was increased from November-December at initiation of new flowering phase and reached highest March onwards at peak flowering stage of sapota coincide with advance fruiting stage during summer. In annual pest calendar, chiku moth bud damage incidence was highest up to 9.44-9.73% in December during 2015-16. Succeedingly during 2016-17, peak bud infestation was noticed to the extent of 8.22 to 10.78% in May and June months as well as 8.81-9.77% in December and then turns down. Similarly during 2017-18, the two phases of infestation were observed *i.e.* during May-June (9.42-10.50%) and November-January (6.34-9.04%) and then decline below 5% bud infestation. The average chiku moth infestation occurrence cycle during April, 2015 to March, 2018 showed peak bud damage during May (8.54-8.86%) and June (7.24-8.00%) and second peak during November (6.19-7.34%), December (8.76-9.42%) and January (6.21-8.08%). The damage to reproductive parts of sapota due to chiku moth during crest flowering phase of April-June affect yield at fruit maturity on January onwards after 10-11 months of fruit development.

The damage distribution pattern of sapota chiku moth (Table 1) indicated that the peak incidence activity was observed during April-June part of main flowering stage (2016-17 and 2017-18) and later during October-December at initiation of new fruiting and foliage phase along with flowering commencement (2015-16, 2016-17 and 2017-18). The bud damage was found consistently low to moderate due to chiku moth during July-September and January-March span. The east and south direction of orchard was slightly more vulnerable to bud damage due to this pest.

The chiku moth bud infestation level in previous findings recorded at same location was low as 4.39% during 2007 and 4.54% in May during 2008 (Anonymous, 2009) and reached to the extent of 5.00 to 6.66% in April to June as well in November-December during 2011-12 (Anonymous, 2013). Such inclination was also noted during 2013 to 2015 with the peak activity during May (5.10-6.27%) and December (6.23-6.76%) at commencement of foliage and flowering phase of sapota cv. Kalipatti (Bisane, 2018). At other sapota growing area, the bud damage due to chiku moth was found between 10.4-18.2% in the span of April to June during 2013 at Periyakulam (T.N.) location (Anonymous, 2015). In contrary with few earlier reports, chiku moth was reported highest during late monsoon period from September onwards under South Gujarat condition (Patel *et al.*, 1993, Anonymous, 1998 and Deshmukh, 2001), while under middle Gujarat, its peak activity reported in July (Patel, 1996) as well as during September in North Gujarat location (Hajare *et al.,* 2012). These data were recorded on Kalipatti variety and difference may be due to ecological and crop phonological stage variability during reporting year.

The linear correlation coefficient of chiku moth incidence with previous and current fortnight weather factors of 2015-16, 2016-17 and 2017-18 was analyzed and is presented in Table 2. The significant positive correlation of chiku moth bud damage with preceding and current bright sunshine hrs as well as negatively with minimum temperature and morning-evening relative humidity was observed during 2015-16.The contrast situation reported during 2016-17, wherein only negative influence of morning relative humidity and positivity of evaporation was found on bud damage when both previous and current fortnightly weather data

Table 3. Regression equations of chiku moth in sapota (2015-18)

Year		Regression Equation	R^2
2015-16	Preceding (All weather factors)	$Y = 12.832 + 0.260 X_1 - 0.316 X_2 - 0.110 X_3 * + 0.008 X_4 - 0.135 X_5 - 0.002 X_6 + 0.107 X_7 + 1.409$	0.73
	Preceding (Five major weather factors)	$Y = 12.401 + 0.217X_1 - 0.255X_2 - 0.111 X_3 * + 0.010X_4 - 0.001X_6 + 1.336$	0.72
	Current (All weather factors)	$Y = 19.300 - 0.008 X_1 - 0.281 X_2 - 0.099 X_3 * - 0.013 X_4 - 0.153 X_5 - 0.000 X_6 + 0.204 X_7 + 1.530$	0.68
	Current (Five major weather factors)	$Y = 19.594 - 0.064 X_1 - 0.180X_2 - 0.098X_3 - 0.021 X_4 + 0.000 X_6 + 1.450$	0.68
2016-17	Preceding (All weather factors)	$Y = 16.817 + 0.042 X_1 + 0.324 X_2 - 0.135 X_3 - 0.090 X_4 - 0.024 X_5 - 0.003 X_6 - 0.237 X_7 + 1.613$	0.60
	Preceding (Five major weather factors)	$Y = 14.441 + 0.033 X_1 + 0.260 X_2 - 0.115 X_3 - 0.073 X_4 - 0.001X_6 + 1.531$	0.60
	Current (All weather factors)	$Y = 21.857 + 0.039 X_1 + 0.149 X_2 - 0.141 X_3 - 0.079 X_4 - 0.439 X_5 - 0.004 X_6 - 0.172 X_7 + 1.862$	0.47
	Current (Five major weather factors)	$Y = 15.659 + 0.006X_1 + 0.167 X_2 - 0.131 X_3 - 0.026X_4 - 0.002 X_6 + 1.919$	0.37
2017-18	Preceding (All weather factors)	$Y = 31.657 + 0.146X_1 - 0.278 X_2 - 0.203 X_3 - 0.031 X_4 - 0.924 X_5 * - 0.006 X_6 + 0.040 X_7 + 1.708$	0.70
	Preceding (Five major weather factors)	$Y = 31.462 + 0.107X_1 - 0.082 X_2 - 0.363 X_3 * + 0.081 X_4 - 0.003X_6 + 2.029$	0.53
	Current (All weather factors)	$Y = 31.598 + 0.085X_1 - 0.521 X_2 * - 0.173 X_3 + 0.041 X_4 - 1.133 X_5 * - 0.004 X_6 + 0.293 X_7 + 1.767$	0.68
	Current (Five major weather factors)	$Y = 36.044 + 0.069X_1 - 0.256X_2 - 0.424X_3 * + 0.169X_4 - 0.002 X_6 + 2.311$	0.38

* Significant at 5% level. X_1 = Maximum temperature; X_2 = minimum temperature; X_3 = morning relative humidity and X_4 = evening relative humidity; X_5 = bright sunshine hrs; X_6 = rainfall and X_7 = evaporation.

correlated. This may be due to unlike incidence pattern during two years. However, preceding rainfall fortnight condition had slight negative influence on bud damage during the both years. During the third year 2017-18, preceding and current morning relative humidity had negative impact on bud damage along with preceding evaporation influence. This showed that chiku moth activity was found fluctuating during investigation period and more associated with crop phenology during flowering and foliage span rather than weather condition. During investigation, only morning relative humidity had influenced chiku moth activity constantly.

The regression equation model of chiku moth incidence (Table 3) indicated that the all the regression coefficients corresponding to all preceding and current weather parameters were found non-significant except morning relative humidity as well as minimum temperature and bright sunshine hrs in few occasion. The extent of variation of chiku moth damage against all the preceding and current fortnightly weather factors was found moderate up to 73 to 68 per cent during 2015-16 with significant impact of morning relative humidity. In five major ecological factors regression model, here also slightly lower 72 and 68 per cent variation noted against preceding and current fortnightly weather data, respectively with only significant influence of morning relative humidity in current weather circumstances. The R^2 value low up to 60 and 47 per cent noted during 2016-17 against all the preceding and current fortnightly weather factors, respectively with non-significant effect. Under five major ecological factors, here also lower 60 and 37 per cent variation noted against preceding and current fortnightly weather data, respectively with non-significant influence of all factors.

Table 4. Bud damage prediction variability due to chiku moth in different phases of crop in sapota

Month	FN	Predicted incidence in 2016-17	Per cent error variation between observed and predicted incidence	Predicted incidence in 2017-18	Per cent error variation between observed and predicted incidence	Predicted incidence in 2018-19	Per cent error variation between observed and predicted incidence	Crop stage
April	I	5.92	-0.64	6.60	0.69	8.55	-11.20	Peak flowering & Fruiting
	II	7.92	-37.40	7.93	-14.15	8.29	1.12	
May	I	9.23	-69.44	8.52	11.93	11.02	-4.99	
	II	8.76	-65.01	9.65	10.49	9.70	7.46	
June	I	9.36	-91.73	7.93	12.99	7.60	24.01	
	II	8.20	-101.53	8.18	0.57	6.79	27.90	
July	I	7.49	-112.19	5.25	21.52	7.99	-10.68	Fruit setting and development
	II	4.43	-52.17	4.66	13.88	5.59	-0.64	
August	I	4.18	-81.27	4.80	0.65	5.64	-94.06	
	II	4.43	-67.57	6.52	-81.34	5.42	-88.71	
September	I	5.70	-146.57	5.61	-60.00	3.67	-32.85	
	II	4.65	-65.02	5.22	-18.75	3.72	-2.41	
October	I	4.33	-15.14	3.18	37.05	3.32	34.00	New foliage & fruiting initiation
	II	4.91	-1.09	5.82	-5.13	1.83	48.10	
November	I	7.03	-7.11	6.47	-1.47	5.87	-4.04	
	II	6.92	16.80	6.25	14.22	6.21	3.23	
December	I	6.21	36.17	6.51	26.17	8.19	-5.93	
	II	6.92	26.71	7.22	26.12	8.25	8.72	
January	I	7.00	20.68	5.75	16.18	6.48	24.25	Peak fruiting & flowering initiation
	II	4.35	40.57	5.13	-3.37	5.08	19.84	
February	I	5.11	12.73	4.86	-44.63	5.41	-4.30	
	II	5.28	-69.00	6.95	-87.75	5.72	-47.54	
March	I	7.62	-97.38	7.12	-31.96	4.77	-71.74	
	II	7.62	-78.09	7.47	-12.06	4.94	-9.43	

As well during 2017-18, the variability was found moderate up to 70 and 68 per cent against preceding and current weather parameters, respectively along with significant impact of bright sunshine hrs. Current minimum temperature also showed effect on infestation level. In five major ecological factors regression model, here also lower 53 and 38 per cent variation noted against preceding and current fortnightly weather data, respectively with only significant influence of morning relative humidity condition.

The prevailing morning relative humidity between 70-80% was noted during high infestation period with more or less in few weeks and only showed effective correlation and regression equation. This indicated that the relative during summer and winter season is more favourable to chiku moth incidence coincide with peak flowering and foliage phase of sapota.

Chiku moth correlation results of present investigation are found comparable with earlier reports wherein no influence of ecological factors on chiku both damage was observed in same agro-ecosystem (Anonymous, 1998), whereas negative link with minimum temperature during 2007-08 and 2008-09 (Anonymous, 2009) on Kalipatti variety reported in south Gujarat condition. While these

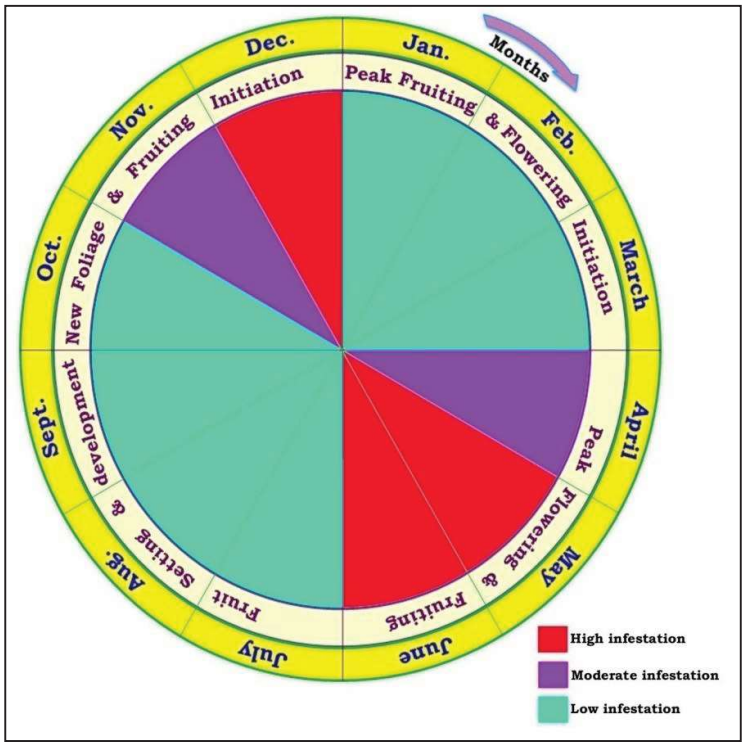

Fig 1. Pest calendar of chiku moth with respect to different phases of crop in sapota

data is slightly conflict with the findings of Patel *et al.* (1993) and Patel (1996), may be due to ecological variability and Location

All the above regression equations values showed that the foremost morning relative humidity effect has augmented the chiku moth incidence in sapota.This finding indicated that there had corresponding influence of crop stage situation for chiku moth incidence at initiation of foliage and flowering phase rather than other major impact of ecological parameters.

The prediction trend model of chiku moth was prepared on the basis of regression coefficient and compared with current year incidence data (Table 4). The results showed that there was increased infestation prediction during 2016-17 of chiku moth damage prepared on the basis of 2015-16 data and found parallel with observed data of May to September and February-March months. There was inclination of chiku moth damage during 2017-18 in the months of August to September and February-March months and found corresponding with actual recorded data. There was no more change in prediction of infestation in other months of crop calendar of all three years.

From the above discussion over present investigation, it can be concluded that chiku moth damage was chiefly linked to crop phenology at flowering as well as foliage and fruiting stage coincide with favourable ecological factors particularly relative humidity in humid and coastal region of south Gujarat.

ACKNOWLEDGEMENT

This work has been carried out with financial support from the Indian Council of Agricultural Research (ICAR) and collaborative organization Navsari Agricultural University, Navsari under ICAR-All India Coordinated Research Project (AICRP) on Fruits. The authors wish to acknowledge the support offered by Director of Research, NAU, Navsari and Officer In-charge of ICAR-AICRP, FRS, NAU, Gandevi in providing the required research facilities particularly.

REFERENCES

Anonymous, 1998. Annual Report 1997-98. All India Coordinated Research Project on Tropical Fruits. Fruit Research Station, NAU, Gandevi. pp. 51-78.

Anonymous, 2009. Biennial Research Report 2007-08 and 2008-09. All India coordinated research project on tropical fruits.Fruit Research Station, NAU, Gandevi. pp. 51-55.

Anonymous, 2013. AICRP Research Report 2013. (Edi.:

Dr A. S. Sidhu; Patil, Prakash and Mrs. Thomas, R.R.). ICAR-IIHR, Bangaluru. pp. 195-222.

Anonymous, 2015. AICRP Research Report 2015, (Edi: Patil, P.; Naduthodi, N.; Shivshankara, K. S.; Reddy, P. V. R.; Sankaran, M.). ICAR-IIHR, Bengaluru. pp. 253-259.

Anonymous, 2017. Horticulture Statistics at A Glance. Horticulture Statistics Division, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.

Bisane, K.D. 2018. Bud borer complex and yield loss in sapota. *Indian Journal of Entomology*, **80**(3): 942-947.

Bisane, K.D., Dhane, A. S., Singh, S. Irulandi, S. and Patil, P. 2018. Insect pests of sapota in India – Monograph. ICAR-IIHR, Bengaluru.

Deshmukh, D.V. 2001. Varietal screening of sapota against pest complex, comparative biology of *Anarsia achrasella* Bradley and bio-efficacy of chemical insecticide against bud boring insets of sapota. M. Sc. (Agri.) thesis, G.A.U., Sardar Krishinagar, India.

Hajare, A.R., Patel, J.I. and Shitole, T.D. 2012. Seasonal incidence of chiku moth *(Nephopteryx eugraphella* R.) in relation to weather parameters. *International Journal of Plant Protection,* **5**(1): 89-92.

Patel, B.S.,Jhala, R.C. and Patel, C.B. 1993. Population dynamics of chiku moth, *Nephopteryx eugraphella* Ragonot (Pyralidae: Lepidoptera) in relation to weather parameter. GAU Res.J., **19**(1): 38-46.

Patel, P.P. 1996. Bionomics and control of chiku moth, *Nephopteryx eugraphella* Ragonot (Pyralidae:Lepidoptera) on sapota *(Achras sapota* Linnaeus) M.Sc. (Agri.) thesis, G.A.U., Sardar Krishinagar, India.

Patel, Z.P. 2002. Insect pests of sapota and their management. In: Management of insect pests, diseases and physiological disorders of fruit crops. pp. 110-113.

MS Received 16 February 2019
MS Accepted 21 March 2019